CLAIMS

1. A fuel composition suitable for use in hybrid rockets and solid fuel ramjets or gas generation, comprising: a fuel disposed in a combustion chamber and means for causing the flow of an oxidizer past the fuel to cause combustion with a flame, characterized in that under the heat transfer from the flame, the fuel forms an unstable melt layer with viscosity and surface tension such that the melted fuel forms droplets that can be entrained in the oxidizer flow thereby increasing the rate of burning of the fuel.

2. The fuel composition of Claim 1 wherein the fuel is selected from the n-alkane class of hydrocarbons and mixtures thereof, having the general formula of $C_n H_{2n+2}$, where n is a mean carbon number and is in the range of 15 to 80, and which are solid at room temperature.

3. The fuel composition of Claim 1 wherein the fuel is selected from the n-alkane class of hydrocarbons and mixtures thereof, having the general formula of $C_n H_{2n+2}$, where n is a mean carbon number and is in the range of 18 to 40.

4. The fuel composition of Claim 1 wherein the fuel is comprised of a material where the viscosity of the melt layer is less than about 1 mPa-sec at an average temperature between the melting and vaporization temperatures of the material, and the surface tension of the melt layer is less than about 25 mN/m at the interface temperature $T_{interface}$.

5. The fuel composition of Claim 2 wherein the fuel is selected from isomers of said alkane class of hydrocarbons.

6. The fuel composition of Claim 1 wherein the fuel is selected from the group of alkhylnaphthalene compounds, anthracene and mixtures thereof.

7. The fuel composition of Claim 1 wherein the fuel is selected from the group of organic acids having the general formula of $CH_3 (CH_2)_nCOOH$ and mixtures thereof, where n is in the range of 8 to 25.

8. The fuel composition of Claim 1 wherein the fuel is selected from the group of n-paraffin compounds and mixtures thereof.

9. The fuel composition of Claim 1 wherein said fuel component further includes one or more additives selected from the group of alcohols, amines, organic acids, carbon black, and mixtures thereof.

10. The fuel composition of Claim 1 wherein said fuel component further includes carbon black at a concentration in the range of about 0.2 to 2.0 weight percent.

11. The fuel composition of Claim 1 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and carbon black in the range of about 0.2 to 2.0 weight percent.

12. The fuel composition of Claim 1 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and one or more polyethylene waxes, or other high molecular weight synthetic waxes.

13. The fuel composition of Claim 1 wherein said fuel component further includes one or more additives to enhance the mechanical properties of said fuel.

14. A method of selecting a propellant that exhibits desirable regression rate during combustion within a port having a gas stream flowing through the port, comprising the steps of:

determining for a given port mass flux, $G = \rho_g U_g$, where ρ_g is the port average gas density and U_g is the port average gas velocity; and

determining for a thickness h of a liquid layer formed on the surface of said fuel;

wherein said port mass flux value and said thickness satisfy the relationship of:

$$G^{1.6} h^{0.6} \geq a_{onset}$$

and where a_{onset} is the entrainment onset parameter and is given by:

$$a_{onset} = 1.05 \times 10^{-2} [\rho_g^{1.3} / \rho_l^{0.3}] [1 / (Cf_{ref} C_{B1})^{0.8}] (1 / \mu_g) \sigma \mu_l^{0.6}$$; and

selecting said propellant such that a_{onset} has a value that promotes entrainment of droplets from said liquid layer into said gas stream flowing in said port, where the units of a_{onset} is $kg^{1.65}/m^{2.3}\text{-}sec^{1.65}$.

15. The method of Claim 14 wherein a_{onset} is equal to or less than approximately 0.9 $kg^{1.65}/m^{2.3}\text{-}sec^{1.65}$.

16. The method of Claim 14 wherein the propellant is selected from the n-alkane class of hydrocarbons, having the general formula of $C_n H_{2n+2}$ and mixtures thereof, where n is a mean carbon number and is in the range of 15 to 80, and which are solid at room temperature.

17. The method of Claim 14 wherein the propellant is selected from the group of alkhyl-naphthalene compounds, anthracene, and mixtures thereof.

18. The method of Claim 14 wherein the propellant is selected from the group of organic acids having the general formula of $CH_3 (CH_2)_n COOH$ and mixtures thereof, where n is in the range of 8 to 25.

19. The method of Claim 14 wherein the propellant is selected from the group of n-paraffin compounds and mixtures thereof.

20. The method of Claim 14 wherein the propellant selected by said method is a fuel or is an oxidant.

21. The method of Claim 14 wherein the propellant is selected from the group of isomers of the alkane class of hydrocarbons.

22. A propellant composition suitable for use in hybrid rockets having a fuel component and an oxidizing component, where one of said components flows past the other component, characterized in that under the heat of combustion the solid component forms an unstable melt layer with viscosity and surface tension such that droplets melt layer are entrained in the gas stream thereby increasing the rate of combustion.

23. The propellant of Claim 22 wherein said propellant is used in solid fuel ramjets.

24. The propellant of Claim 22 wherein the fuel is selected from the n-alkane class of hydrocarbons, having the general formula of $C_n H_{2n+2}$ and mixtures thereof, where n is a mean carbon number and is in the range of 15 to 80, and which are solid at room temperature.

25. The propellant of Claim 22 wherein the fuel is selected from the n-alkane class of hydrocarbons, having the general formula of $C_n H_{2n+2}$ and mixtures thereof, where n is a mean carbon number and is in the range of 18 to 40.

26. The propellant of Claim 22 wherein the fuel is comprised of a material where the viscosity of the melt layer is less than about 1 mPa-sec at an average temperature between the melting and vaporization temperatures of the material, and the surface tension of the melt layer is less than about 25 mN/m at the interface temperature $T_{interface}$.

27. The propellant of Claim 22 wherein the fuel is selected from the group of alkhyl-naphthalene compounds, anthracene and mixtures thereof.

28. The fuel composition of Claim 22 wherein the fuel is selected from the group of organic acids having the general formula of $CH_3 (CH_2)_n COOH$ and mixtures thereof, where n is in the range of 8 to 25.

29. The propellant of Claim 22 wherein the fuel is selected from the group of n- paraffin compounds and mixtures thereof.

30. The propellant of Claim 22 wherein said fuel component further includes one or more additives selected from the group of alcohols, amines, organic acids, carbon black, and mixtures thereof.

31. The propellant of Claim 22 wherein said fuel component further includes carbon black at a concentration in the range of about 0.2 to 2.0 weight percent.

32. The propellant of Claim 22 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and carbon black in the range of about 0.2 to 2.0 weight percent.

33. The propellant of Claim 22 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and one or more polyethylene waxes or other high molecular weight synthetic waxes.

34. The propellant of Claim 22 wherein said fuel component further includes one or more stiffening agents.

35. A propulsion system including a structure terminating in a nozzle and having a fuel component within the structure, one or more ports formed within, or containing, the fuel component, and an oxidant vessel within the vehicle structure for flowing oxidant in contact with said one or more ports to combust said fuel component, characterized in that the

fuel is selected such that under the heat of combustion, the fuel forms an unstable melt layer with viscosity and surface tension such that droplets of the melted fuel are entrained in the flowing oxidant thereby enhancing the burning rate of the fuel.

36. The propulsion system of Claim 35 wherein the fuel is selected from the n-alkane class of hydrocarbons, having the general formula of C_nH_{2n+2} and which are solid at room temperature.

37. The propulsion system of Claim 35 wherein the fuel is selected from the n-alkane class of hydrocarbons, having the general formula of C_nH_{2n+2} and mixtures thereof.

38. The propulsion system of Claim 35 wherein the fuel is comprised of a material where the viscosity of the melt layer is less than about 1 mPa-sec at an average temperature between the melting and vaporization temperatures of the material, and the surface tension of the melt layer is less than about 25 mN/m at the interface temperature $T_{interface}$.

39. The propulsion system of Claim 35 wherein the fuel is selected from the group of alkhylnaphthalene compounds, anthracene and mixtures thereof.

40. The propulsion system of Claim 35 wherein the fuel is selected from the group of organic acids having the general formula of $CH_3 (CH_2)_n COOH$ and mixtures thereof, where n is in the range of 8 to 25.

41. The propulsion system of Claim 35 wherein the fuel is selected from the group of n-paraffin compounds and mixtures thereof.

42. The propulsion system of Claim 35 wherein said fuel component further includes one or more additives selected from the group of alcohols, amines, organic acids, carbon black, and mixtures thereof.

43. The propulsion system of Claim 35 wherein said fuel component further includes carbon black at a concentration in the range of about 0.2 to 2.0 weight percent.

44. The propulsion system of Claim 35 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and carbon black in the range of about 0.2 to 2.0 weight percent.

45. The propulsion system of Claim 35 wherein said fuel component is comprised of a mixture of one or more paraffin waxes and one or more polyethylene waxes or other high molecular weight synthetic waxes.

46. The propulsion system of Claim 35 wherein said fuel component further includes one or more stiffening agents.

47. A combustible hybrid fuel having a solid fuel component, and a flowing oxidizing component flowing through a port in the solid fuel component, characterized in that:

said solid fuel component is comprised substantially of one or more materials that form a liquid layer at the interface between the flowing oxidizing component and the solid fuel component during combustion by the oxidizing component, and

wherein said liquid layer exhibits entrainment of liquid droplets in the flowing oxidizing component during combustion at an entrainment rate expressed as:

$$\dot{r}_e \propto \frac{(C_f P_d)^{\alpha} h^{\beta}}{\sigma^{\gamma} \mu_l^{\delta}} \qquad (23)$$

where r_e is the empirical expression for the entrainment rate of the liquid droplets, P_d is a dynamic pressure of the oxidizing component flow in the port, h is the thickness of the liquid layer, μ is the viscosity of the liquid layer, and σ is the surface tension of the liquid layer, and β is approximately 2, α is approximately 1.5, and γ and δ are both approximately 1.

48. The method of Claim 14 used to select a propellant that will exhibit a regression rate tailored to a particular application or mission.